Environment Canada / Environnement Canada
Conservation and Protection / Conservation et Protection

A State of the Environment Fact Sheet

Trends in contaminant levels in the Niagara River

Niagara Falls, located roughly 20 km upstream of where the Niagara River enters Lake Ontario (Fig.1), has often been described as one of the "seven wonders of the world." It has long been one of North America's favourite scenic locations. Every year, many thousands of visitors marvel at the spectacle of the immense flow of water cascading over the falls en route from Lake Erie to Lake Ontario — an average of 5.7 million litres per second.

In recent decades, with the release of numerous reports documenting a diverse range of contaminants[1] in the Niagara River's waters, awed spectators have begun to ponder the quality of this enormous quantity of fresh water. They have also begun to question the effects of this pollution on the health of the biota of the Niagara River and the residents living along it as well as on the health of all ecosystems to which it is so inextricably linked. For example, the Niagara River alone accounts for roughly 83% of the total tributary inflow to Lake Ontario, from which the waters then pass on to the St. Lawrence River and the Atlantic Ocean beyond.

The Niagara River alone accounts for roughly 83% of the total tributary inflow to Lake Ontario

Figure 1
The Niagara River region

Source: Malcomson (1987).

The quality of Niagara River water therefore has important implications not only for its own ecological health but also for that of all downstream ecosystems, some of which serve as sources of drinking water for millions of Canadian and American residents. What is being done to clean up the Niagara River, and are these efforts working? This fact sheet examines recent trends in concentrations of various contaminants in the Niagara River in an attempt to answer these questions.

A history of stress

Throughout the 1900s, the Niagara River, along with many other parts of the Great Lakes basin, has experienced an array of problems related to ecological degradation. These problems have been associated with a very diverse range of contaminants.

In 1918, the newly formed International Joint Commission, an organization involving Canadian and U.S. participation, first reported on pollution in the Niagara River. The problem then was bacteria, because almost no sewage was being treated before being dumped into the river. Drinking water from the Niagara River was threatened, people began dying from cholera and typhoid fever, and many public beaches along the shores of Lake Ontario were forced to close.

[1] In this fact sheet, the term *contaminants* is used to refer to water quality parameters (e.g., nitrogen, phosphorus, chloride) that are naturally found in water, together with biological (e.g., bacteria) and chemical (e.g., chlorinated benzenes, lead) substances that are introduced into the ecosystem by humans, either directly or indirectly. Contaminants that result or are likely to result in deleterious effects (e.g., causing harm to humans and other living organisms or hindering human activities) can also be characterized as *pollutants.*

In 1950, the International Joint Commission reiterated its concerns about high levels of bacteria in the Niagara River and diagnosed several new ecological problems, including excessive concentrations of phenols, crude oil, metals, phosphorus, and chloride in the river, as well as discolouration of the water. The issue of eutrophication was of particular concern, as it appeared that the lower Great Lakes were choking to death on the overly abundant growth of algae and other aquatic plants caused by excess phosphorus.

The economic boom of the 1960s led to an increase in chemical production in the Great Lakes basin, and toxic substances such as mercury, polychlorinated biphenyls (PCBs), and dichlorodiphenyltrichloroethane (DDT) began to be detected in the lakes and rivers of the basin. In 1977, the Love Canal toxic waste dump and other chemical dumps in and around Niagara Falls, New York, were found to be leaking into the Niagara River. In 1978, the Water Quality Board of the International Joint Commission compiled a list of 500 contaminants found in the air, water, land, and biota of the Great Lakes basin, including the Niagara River.

A few characteristics of the Niagara River

Length:	58 km from Lake Erie to Lake Ontario
Width:	Ranges from less than 150 m to 2 150 m
Shoreline length:	110 km
Channel depth:	Ranges from 1 m to 50 m
Velocity:	Ranges from 0.3 to 10 m/s, with its highest velocity under the Peace Bridge in Fort Erie and in the rapids below Niagara Falls
Average discharge:	5 700 m^3/s, and provides 83% of the total tributary flow to Lake Ontario
Flow time:	15 to 18 h
Drainage basin:	Drains 227 000 km^2
Population:	Provides 930 000 people in Canada and the United States (including Buffalo, New York) with drinking water
Vertical drop:	100 m from Lake Erie to Lake Ontario (half of which is at Niagara Falls)

How can one visualize ppm, ppb, and ppt?

Parts per million (ppm), parts per billion (ppb), and parts per trillion (ppt) have become commonly accepted terms used to express concentrations or levels of contaminants in air, soil, water, and tissues. The following rough comparisons may help you to picture the concentrations of contaminants discussed in this fact sheet:

1 part per million =	one thimbleful (about 1.5 mL in size) of a contaminant in four to five average-sized bathtubs of water
1 part per billion =	one thimbleful of a contaminant in two Olympic-sized swimming pools
1 part per trillion =	one thimbleful of a contaminant in 2 000 Olympic-sized swimming pools, or 1 640 1-L milk cartons of a contaminant in all of Lake Ontario

These comparisons illustrate just how low concentrations of chemical contaminants can be in some cases. Unfortunately, certain chemicals are harmful to organisms, especially animals high in a food web, even at incredibly low levels. For example, it is believed that as little as 5 kg of 2,3,7,8-TCDD could make Lake Ontario completely unsafe for drinking, whereas there is an estimated 1 t of this chemical in the wastes of just one of the big chemical dumps along the shore of the Niagara River (Keating 1986).

Monitoring contaminant levels

By the 1950s, the Niagara River had reached a low point in terms of its water quality, even though most of its earlier problems, such as bacterial contamination, had been dealt with. In response to concerns about levels of a diverse range of contaminants in the river and its wildlife, various environmental agencies began monitoring the water and suspended sediments of the Niagara River.

A number of programs are currently in place to monitor these contaminants. Since 1975, for example, Environment Canada has operated a permanent monitoring station at Niagara-on-the-Lake, just upstream of where the Niagara River enters Lake Ontario. The data from this station are significant because they represent one of the longest continuous sets of such data available for the Great Lakes basin. As well, the location of the station itself is representative of water entering Lake Ontario from the Niagara River (Chan 1977; Green 1988).

Monitoring the levels of contaminants in water can be a difficult exercise, mainly because the concentrations to be measured are extremely low, in the parts per billion range or less. Indeed, it is only since the early 1980s that chemists have had the technology necessary to measure such minuscule quantities. As a result, long-term trends for many contaminants are difficult to discuss, because older methods may have been unable to detect or correctly identify the contaminants of interest in water samples or may have given inaccurate results.

Monitoring levels of contaminants in the Niagara River's surface waters tells only part of the story with respect to the health of the ecosystem. To begin with, contaminants often do not persist for long as independent entities in surface waters. If toxic chemicals, for example, do not break down into smaller molecules, they may attach themselves to suspended particles and eventually become part of the bottom sediments. In this way, the legacy of pollution endures, and the contaminants can remain a threat for a very long time.

Alternatively, contaminants may be ingested and become part of the food web. It is therefore also important to monitor levels of contaminants in tissues of organisms. Plants and animals have a strong tendency to take up and store contaminants in their tissues (bioaccumulation); as well, contaminants tend to cumulatively increase in concentration at successively higher levels in the food web (biomagnification). These processes therefore significantly enhance the threat that contaminants pose to the aquatic ecosystem and to human health.

For all these reasons, scientists often prefer to monitor the presence of contaminants in those parts of the environment where they accumulate, such as in suspended sediments and in living matter such as algae, plankton, fish, birds, and other forms of wildlife. Fish and birds are the most commonly used monitors of contaminants. Being high in the food chain, they contain larger, more easily measured quantities of bioconcentrated contaminants than lower life forms. They also give some indication of the biological effects of these substances.

In response to concerns about levels of a diverse range of contaminants in the river and its wildlife, various environmental agencies began monitoring the water and suspended sediments of the Niagara River

Current trends

Recent trends in concentrations of nutrients, sodium and chloride ions, metals, and toxic chemicals in water, suspended sediments, and biota of the Niagara River ecosystem are described below. Knowledge of these trends is important for determining the success of cleanup efforts in the region and for evaluating progress towards sustaining the health of the ecosystem.

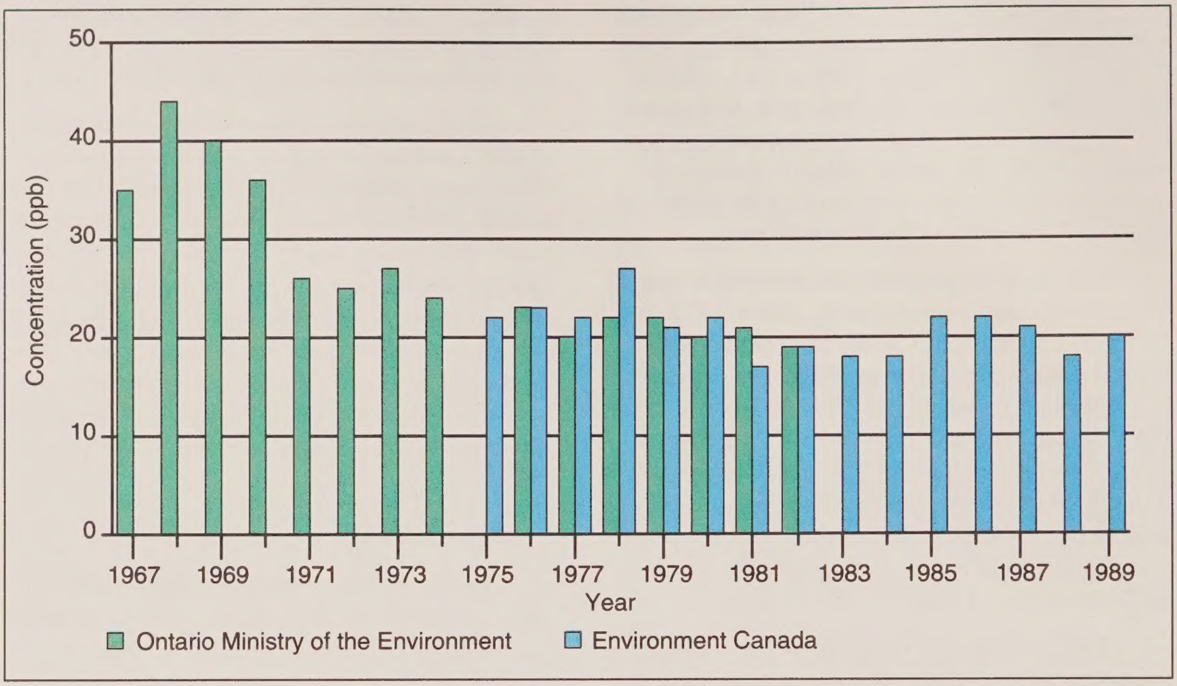
It is only since the early 1980s that chemists have had the technology necessary to measure the minuscule quantities of some contaminants present in water

Nutrients

Both phosphorus and nitrogen are essential nutrients for the growth of algae and other aquatic plants. Unfortunately, when present at high levels as a result of human activity, they accelerate the natural process of *eutrophication* — the overfertilization of water bodies that causes excessive growth of these plants. One consequence of this excessive growth is the depletion of dissolved oxygen, which is required by aquatic organisms for their survival. Another result is the fouling of beaches by masses of smelly, rotting algae washing in from the river or lake.

Eutrophication was the principal focus of the historic first Canada–U.S. Great Lakes Water Quality Agreement, signed in 1972. The problem was addressed primarily through the control of phosphorus, which was considered to be the element that most affected the growth of algae and other aquatic plants. Initial efforts were directed at reducing phosphorus inputs from *point sources*

Figure 2
Concentrations of total phosphorus in the Niagara River, 1967–89



Source: Ontario Ministry of the Environment and Environment Canada (Water Quality Branch).

Notes: OME data were collected during the summer months at a range of stations near Niagara-on-the-Lake. Environment Canada data are annual mean values from samples collected throughout the year at the permanent station at Niagara-on-the-Lake.

(that is, identifiable, distinct sources, such as municipal sewage outflows and industrial effluent pipes). Measures taken included upgrading sewage treatment plants as well as reducing the phosphate content of laundry detergents. In 1983, a supplement to the 1978 Great Lakes Water Quality Agreement further strengthened the program to control phosphorus with commitments to curtail inputs from *non-point sources*, such as agricultural and urban drainage or runoff. Figure 2 shows that total phosphorus concentrations in the Niagara River have decreased substantially since the late 1960s.

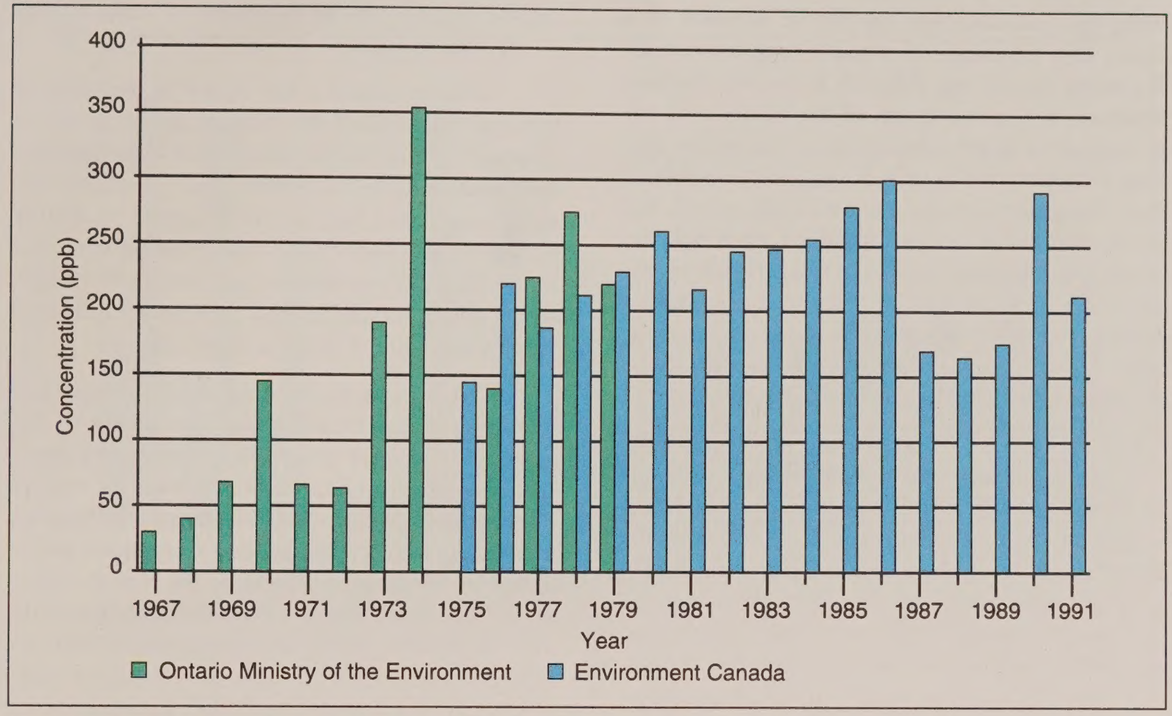
In general, it is more difficult to regulate nitrogen inputs to aquatic ecosystems than it is to regulate phosphorus inputs; this is because nitrogen sources, such as atmospheric deposition and agricultural runoff, are much more diffuse than phosphorus sources. Increases in the use of agricultural fertilizers and in the deposition of nitrogen compounds by acidic precipitation over the last decades have therefore resulted in substantial increases in concentrations of nitrogen (in the form of nitrate plus nitrite) in the Niagara River between 1967 and 1986 (Fig. 3).

On the other hand, except for 1990, the Niagara River demonstrated significant decreases in nitrate plus nitrite concentrations after 1986 (Fig. 3). The reasons for these decreases are not yet understood, but they may be related to the dry, hot summers experienced during these years — reduced precipitation may have led to reduced input of nutrients from surface drainage and acidic deposition. As well, algal productivity in Lake Erie may have increased, resulting in a greater uptake of nutrients from the water before it reached the Niagara River.

Sodium and chloride ions

Sodium and chloride, which are constituents of everyday table salt, are the principal ions found in marine waters but are usually present in low concentrations in fresh waters. Up to the mid-1970s, these two ions were increasing in concentration in the Niagara River and other parts of the Great

Figure 3
Concentrations of nitrate plus nitrite in the Niagara River, 1967–91



Source: Ontario Ministry of the Environment and Environment Canada (Water Quality Branch).

Notes: OME data were collected during the summer months at a range of stations near Niagara-on-the-Lake. Environment Canada data are annual mean values from samples collected throughout the year at the permanent station at Niagara-on-the-Lake.

Lakes basin (e.g., Beeton and Edmondson 1972), probably as a result of industrial discharges and an increase in winter road salting, which uses sodium chloride as one of the main active ingredients. Because sodium and chloride are not used in the biological cycle in the Great Lakes basin and do not evaporate or settle out, scientists became concerned that sensitive freshwater biota would not be able to tolerate the increased salt levels in the water.

Since the mid-1970s, however, sodium and chloride have shown marked decreases in concentration in the Niagara River. Chloride concentrations, for example, have decreased by nearly 26%, from a peak of 22.2 ppm in 1977 to 16.5 ppm in 1991 (Kuntz 1988; Kuntz and Tsanis 1990; unpbl. data). A significant portion of this reduction is believed to be due to a major decline, since the early 1970s, in inputs of chloride to the Detroit River by several major industries (Sonzogni *et al.* 1983; Whyte 1986). This would have resulted in a reduction in the input of chloride to Lake Erie from the Detroit River, with subsequent decreases in the downstream waters of the Niagara River. Winter road de-icing also has diminished in the Lake Erie drainage basin and could account for some of the observed decrease in concentrations of these ions.

Sodium and chloride have shown considerable decreases in concentration in the Niagara River since the mid-1970s

Metals

Minute quantities of some metals are essential to life. Other metals, however, may be harmful to organisms at all levels of an ecosystem at extremely low concentrations. Examples abound of the toxic effects of metals on aquatic organisms, from phytoplankton through invertebrates to fish. Mercury at concentrations as low as 0.2 ppb can be extremely toxic to fish; lead at concentrations of 1–7 ppb can cause blackening of the tail and spinal curvature in fish (Government of Canada 1991); and zinc at concentrations as low as 70 ppb can exert chronic toxic effects on invertebrates and fish (CCREM 1987).

Methods for measuring trace levels of metals in water have improved since the early 1970s, lowering the concentration that can be detected by a factor of a thousand. As a result, long-term trends for many metals are difficult to assess, because detection and measurement of the metals were not as accurate with the older methods. In contrast, analytical methods for metals in suspended sediments have remained about the same over this period, and so the discussion of their trends is more reliable. Metal concentrations tend to be much higher in suspended sediments than in open water, as metals become bound to, and therefore a part of, the particles. As such, they do not cycle as readily in the ecosystem, but they nonetheless serve as sources of these contaminants to the waters over the long term.

Lead and zinc will be used to illustrate trends in metal concentrations in the Niagara River ecosystem over the last decade. Lead can enter the environment from many sources, including leaded gasoline, mining and smelting of lead-bearing ores and metals, lead plumbing and solder, paints, and the careless disposal of lead–zinc batteries in landfill sites (Government of Canada 1991). Zinc enters the environment through both natural (e.g., natural weathering, erosion) and anthropogenic (e.g., primary zinc production, wood combustion, waste incineration, iron and steel production, municipal wastewater) processes (CCREM 1987).

Figure 4 shows that mean concentrations of both extractable lead and zinc in Niagara River suspended sediments have decreased considerably since 1978. Lead concentrations decreased from a mean of 78.4 ppm in 1978 to 32.5 ppm in 1991. This decrease is probably a result of the gradual phasing out of leaded gasoline use in Canada, because of concerns regarding the toxic effects of lead on humans, particularly children. Zinc concentrations decreased over the same period from 175.7 ppm to 98.6 ppm. The reasons for this decrease are unknown.

Decreases in lead concentrations between 1978 and 1991 are probably a result of the gradual phasing out of leaded gasoline use in Canada

Toxic chemicals

One-quarter of U.S. chemical companies are in the Great Lakes region, many of them along the Niagara River (Keating 1986). On the U.S. side, 215 hazardous waste disposal sites are located within the Niagara River drainage basin (Government of Canada 1991). Of these, 164 are within 5 km of the river. Four major sites alone (Love Canal, 102nd Street, S-Area, and Hyde Park; Fig.1) contain 304 000 t of chemical waste. All are connected by groundwater to the Niagara River, and all are considered to have off-site movement of contaminants via the groundwater.

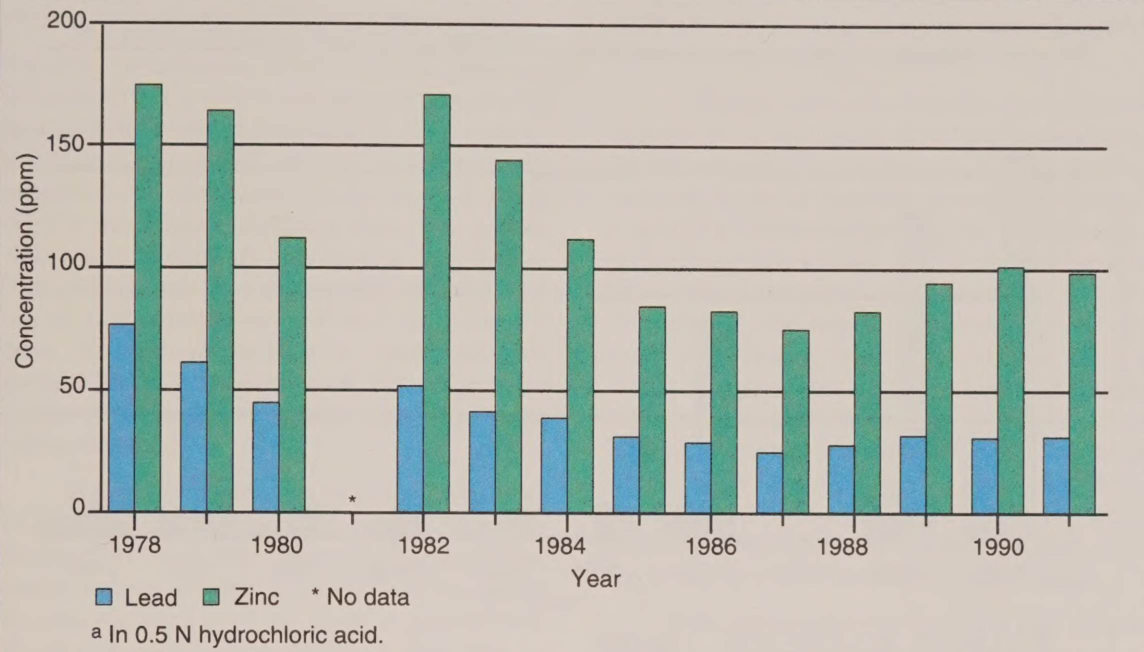
Groundwater is a key factor in the story of the contamination of the Niagara River, as it is a principal vehicle for the transport of chemical contaminants to the river. Further, because groundwater movement is very slow compared to that of surface water, sometimes measurable in centuries rather than days or months, any action that negatively affects its quality may profoundly influence the quality of life of future generations.

The dozens of hazardous waste sites and operating plants located along the length of the Niagara River have proved to be the largest single source of toxic chemicals entering its waters (Government of Canada 1991). In its 1990 report, the Niagara River Coordination Committee established the presence in or input to the Niagara River of 342 chemicals that are potentially toxic to wild and domestic plants and animals as well as humans. Eleven of these substances have been labelled by the International Joint Commission as "critical pollutants ... capable of producing adverse, often irreversible effects in a wide range of mammalian and aquatic species."

Concentrations of organic chemicals in water are often difficult to quantify and interpret because they are generally near the limits of analytical detection and are, therefore, subject to high uncertainty. In the Niagara River, this problem is compounded by the immense dilution effects of the river's high flows and the considerable variation that occurs in its suspended sediment load. As was the case with metals, methods for measuring concentrations of organic chemicals in water have improved many times over the last two decades. These improvements have reduced detection limits from the ppm to the ppt level, or one million times lower. These changes in methods make a discussion of trends difficult, because of the lower precision of the older techniques.

The data base on chemical contaminant loadings to the Niagara River remains limited, and in many instances we do not know where the chemicals are coming from or where they are going. Nonetheless, the Niagara River monitoring program provides some of the best quantifications of toxic chemicals in North America. A few organic

Figure 4
Mean concentrations of extractable[a] lead and zinc in suspended sediments in the Niagara River, 1978–91



Source: Environment Canada (Water Quality Branch).

chemicals of interest, for which the most reliable measurements have been made by several different laboratories, will be used to illustrate that, in general, levels of toxic chemical contaminants appear to have decreased in the Niagara River since the early 1980s.

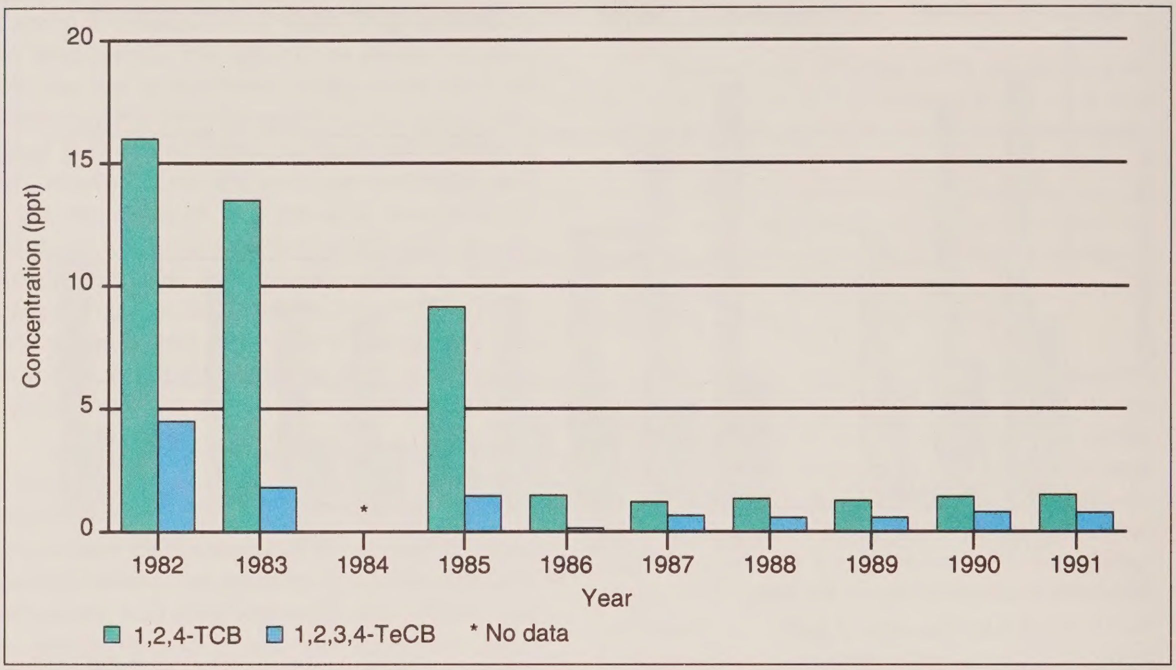
Chlorinated benzenes can enter the aquatic environment as a result of their use in industrial processes, in solid and liquid industrial effluents, and in atmospheric discharges; as well, chlorination of municipal sewage wastewater containing small amounts of benzene and benzene derivatives may produce low levels of a variety of chlorinated benzenes. The presence of these compounds in water is of concern because of the consistent, direct relationship between the degree of chlorination of benzene and toxicity to fish, invertebrates, and plant species (CCREM 1987).

In 1982, two chlorinated benzene compounds, 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene — used, for example, as intermediates in chemical synthesis, as solvents, and as insecticides (WHO 1993) — were found at mean concentrations of 16.0 ppt and 4.5 ppt, respectively, in Niagara River water (Oliver and Nicol 1984). By 1991, however, these compounds had decreased significantly in concentration, to about 1.6 ppt and 0.8 ppt, respectively (Fig. 5). One possible explanation for the decrease in levels of both chlorobenzenes is the reduction in point source inputs of these contaminants to the Niagara River. In addition, much of this reduction may be attributed to the installation of a carbon treatment facility at the sewage treatment plant in Niagara Falls, New York, which became operational in August 1985.

Many organic chemical compounds are strongly adsorbed onto suspended sediments. Concentrations on suspended sediments are, therefore, often higher and hence easier to measure than concentrations in the water. PCBs are another class of organic chemicals of environmental interest because of their widespread use, persistence in water, tendency to be biomagnified in food webs, and potential to harm human health. Concentrations of total PCBs in suspended sediments decreased dramatically between 1979 and 1991, from over 650 ppb to about 150 ppb (Fig. 6). This decrease illustrates the general trend in concentrations of

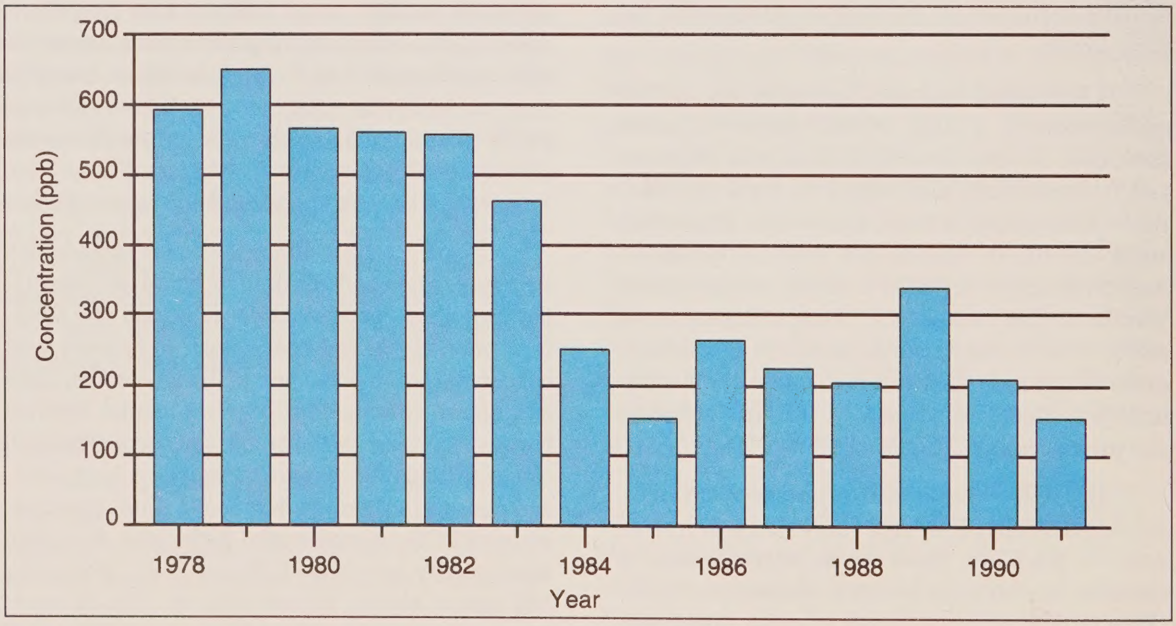
The Niagara River monitoring program provides some of the best quantifications of toxic chemicals in North America

Figure 5
Concentrations of 1,2,4-trichlorobenzene (1,2,4-TCB) and 1,2,3,4-tetrachlorobenzene (1,2,3,4-TeCB) in water of the Niagara River, 1982–91



Source: Oliver and Nicol (1984) (1982 data); Carey and Fox (1987) (1983 data); Environment Canada (Water Quality Branch) (1985–91 data).

Figure 6
Concentrations of PCBs in suspended sediments of the Niagara River, 1978–91



Source: Environment Canada (Water Quality Branch).

several other chemical contaminants on suspended sediments observed from the late 1970s to the early 1990s.

The problems associated with measuring very low concentrations of chemicals in water can be avoided to a considerable extent by monitoring accumulated levels of chemicals in the tissues of organisms, as levels of chemical contaminants in organisms are usually sufficiently high to obtain reliable quantitative analytical data. The spottail shiner, a nonmigratory fish species with a relatively short life cycle, is particularly well suited for use as an environmental indicator for localized areas. By measuring changes in concentrations of chemicals in its tissues over time, changes in water quality of the local area over the same time frame can be inferred.

Figure 7 shows trends in concentrations of PCBs and DDT in Niagara River spottail shiners between 1975 and 1991 (Suns *et al.* 1991). Tissue concentrations of both chemicals have decreased dramatically since 1975, by about a factor of five. These decreases can be explained primarily by reductions in use. Most uses of DDT were banned in 1970 in Canada and in 1973 in the United States because of its persistence, its tendency to bioaccumulate, and its association with deformity and reproductive failure in fish and birds. Most uses of PCBs have been restricted since 1980 in both countries. Nonetheless, as of 1991, concentrations of PCB residues in spottail shiners continued to exceed an objective, 100 ppb, based primarily on a threshold level for the protection of fish-eating birds.

Implications for human health

The waters of the Niagara River feed directly into Lake Ontario. Concerned about the quality of Niagara River water, many residents of Niagara-on-the-Lake refuse to drink the outflow of the Niagara River and instead have pressured provincial and local governments to supply them with water from another source.

The residents of Niagara-on-the-Lake are not the only inhabitants of the Great Lakes basin that are concerned about risks to their health from contaminated drinking water. Almost one million people on both sides of the Niagara River obtain their drinking water directly from the river. In addition, some four million Ontarians and one million New York residents draw their drinking water from Lake Ontario, and a further three million Quebec residents get their drinking water from the St. Lawrence River farther downstream (Keating 1986).

Although contaminated drinking water is uppermost in the minds of residents concerned about pollution in the Niagara River, drinking water is, in fact, a relatively insignificant route of exposure to most contaminants for humans living in the Great Lakes ecosystem. In fact, for humans, the major contaminant exposure route (75%) is through the consumption of food, with air and water contributing only 10% and 15%, respectively, of daily exposure (Government of Canada 1991). Although humans may be threatened by long-term exposure to even low levels of certain chemicals in food (Government of Canada 1991), the biomagnification process increases the likelihood that consumption of organisms higher up in the food web will be harmful to human health.

Fish consumption advisories, a sign of serious pollution, exist for the Niagara River and 30 other areas in the Great Lakes basin. The Government of Ontario publishes a *Guide to eating Ontario sport fish*, which includes guidelines for consumption of fish caught in the Niagara River (OME/OMNR 1991). The guidelines identify fish species, sizes of fish, and locales in which fish are too contaminated to be eaten.

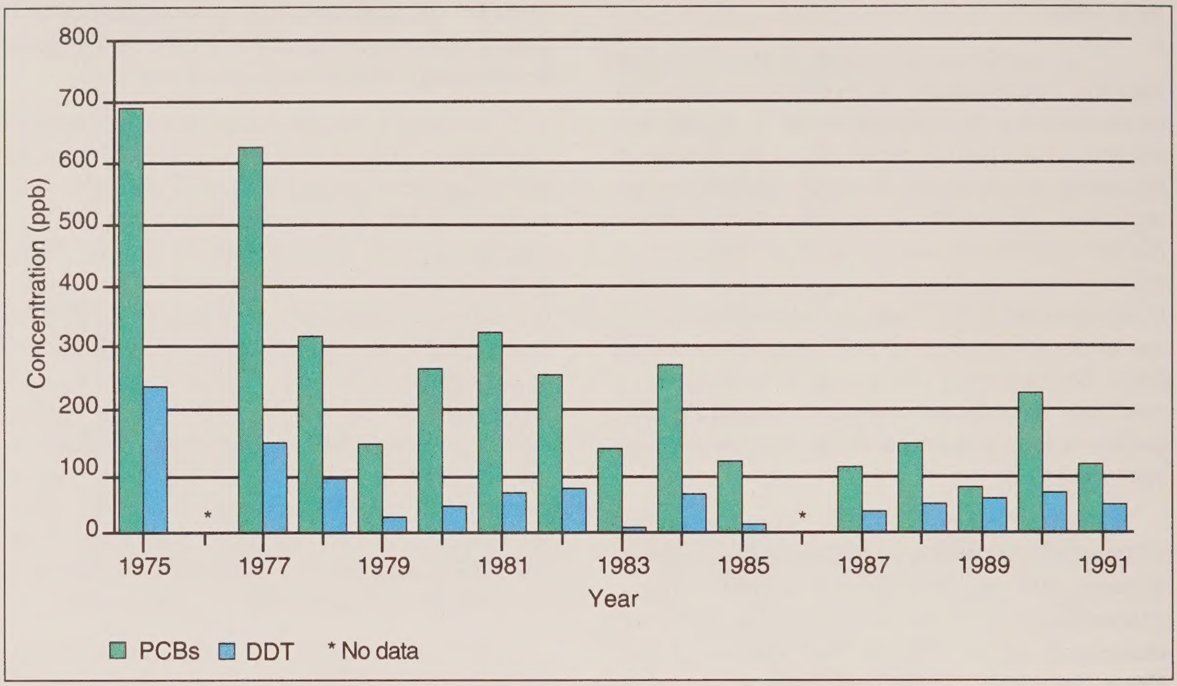
In general, it is difficult to evaluate the effects of the Niagara River on its people. Nevertheless, efforts to clean up the river continue in an attempt to reduce the risk to human health.

What is being done to restore the health of the ecosystem?

Inputs of toxic industrial waste and municipal sewage over the years have degraded the Niagara River. Up until the last few years, cleanup of the river, along with that of the Great Lakes basin overall, was characterized by a "react and cure" approach to addressing environmental concerns. Eighty years ago, for example, the response to the problems caused by the input of human sewage to water bodies was the chlorination of drinking water to kill the disease-causing bacteria. Eliminating the discharge of raw sewage into the

The decrease in concentrations of total PCBs illustrates the general trend in concentrations of chemical contaminants on suspended sediments observed from the late 1970s to the early 1990s

Figure 7
Concentrations of PCBs and DDT in spottail shiners of the Niagara River, 1975–91



Source: Ontario Ministry of the Environment; Suns *et al.* (1991).

water to prevent the problems in the first place did not begin for several more decades.

The same story holds true for many other contaminants polluting the Niagara River. Cleanup after the fact is generally considerably more expensive than prevention. This is proving to be the case with the Niagara River.

Great Lakes Water Quality Agreement

The *Great Lakes Water Quality Agreement* was first signed in 1972 by Canada and the United States and was renewed in 1978. This agreement commits each country to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes ecosystem and includes a number of objectives and programs to achieve this goal. In 1987, a protocol was signed amending the 1978 agreement. The amendments strengthen the programs and other measures described in the prior agreement and increase accountability for their implementation. The agreement recognizes that solutions to the problems in the Great Lakes ecosystem require programs that address "the linkages between all components of the ecosystem — air, land, water, wild plants and animals, and humans and their activities."

Most of the data on trends in contaminant levels in the Niagara River described in this fact sheet have been collected as part of Canada's commitment to the Great Lakes Water Quality Agreement.

Niagara River Remedial Action Plan

Since 1973, the whole of the Niagara River has been designated as an *area of concern* — one of 43 "toxic hot spots" in the Great Lakes basin identified by the International Joint Commission. An area of concern is a geographical area that fails to meet the objectives of the Great Lakes Water Quality Agreement, where such failure has caused or is likely to cause impairment of the area's ability to support aquatic life or its beneficial use by humans (Niagara River Remedial Action Plan Public Advisory Committee 1991). In each of these areas of concern, water quality is seriously impaired, and the problem of water pollution typically is severe and has been long-standing. Remedial or cleanup measures are necessary to restore ecosystem health.

Remedial Action Plans have been or are being developed to restore ecosystem quality in all 17 areas of concern on the Canadian side of the Great Lakes basin, and similar efforts are under way in areas of concern on the U.S. side of the border. These plans identify environmental conditions and problems, as well as specific measures necessary to improve ecosystem health. A Remedial Action Plan, which embodies a comprehensive ecosystem approach to problem resolution, is being developed to "re-establish, protect, and maintain the integrity of the ecosystem for the Niagara River" (Niagara River Remedial Action Plan Public Advisory Committee 1991).

The Niagara River Area of Concern and its problems are divided between Canada and the United States. Its solutions, therefore, are also divided. While a plan is being developed to repair what has been happening on the Ontario side of the river, a separate Remedial Action Plan is being prepared to address a problem of much greater magnitude on the U.S. side. Each plan is being developed to address the problem in the context of the total Niagara River ecosystem.

Niagara River Declaration of Intent

In February 1987, the environmental agencies of Canada, Ontario, the United States, and New York signed the *Niagara River Declaration of Intent* which committed the agencies to a 50% reduction, by 1996, in inputs of selected persistent toxic chemicals to the Niagara River (Malcomson 1987). The agreement contains a timetable for action that would reduce discharges of toxins into the river. Various ways of cleaning up the most dangerous toxic dump sites are also being considered.

The cleanup accord reflects a move in Canada and the United States towards implementing pollution prevention programs that, instead of requiring pollution sources to meet a certain criterion for toxic chemicals, will suggest "zero discharge" or "virtual elimination" of specific persistent toxic substances from waste streams. This new approach on the part of agencies responsible for the implementation of these strategies depends on continued strong support from the public.

Conclusions

Although there are still hundreds of potentially harmful compounds in the Great Lakes ecosystem, water, suspended sediments, and indicator species of algae, fish, and other wildlife have shown a general reduction in contaminant levels over the last two decades. This reduction has now levelled off, however, which suggests that, although the extent of the problem will likely never be as bad as it was, further controls of loadings will be required if levels are to drop any further. Even if loadings are completely stopped, it may take decades, even centuries, to cleanse the ecosystem of its persistent contaminants (Keating 1986). Nevertheless, all the actions currently being taken, together with increased public awareness, should enable continued progress to be made in the improvement of the quality of water in the Niagara River and elsewhere in the Great Lakes basin.

A Remedial Action Plan is being developed to "re-establish, protect, and maintain the integrity of the ecosystem for the Niagara River"

In February 1987, the environmental agencies of Canada, Ontario, the United States, and New York signed the *Niagara River Declaration of Intent*, which committed the agencies to a 50% reduction, by 1996, in inputs of selected persistent toxic chemicals to the Niagara River

References

Beeton, A.M. and W.T. Edmondson. 1972. The eutrophication problem. Journal of the Fisheries Research Board of Canada 29:673–682.

Carey, J.H. and M.E. Fox. 1987. Distribution of chlorinated benzenes in the Niagara River plume. National Water Research Institute Contribution No. 87–86.

CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian water quality guidelines. Ottawa: Canadian Council of Resource and Environment Ministers, Task Force on Water Quality Guidelines.

Chan, C.H. 1977. Water quality surveys on the Niagara River — 1974. Report Series No. 48. Burlington, Ontario: Environment Canada, Inland Waters Directorate, Water Quality Branch, Ontario Region.

Government of Canada. 1991. The state of Canada's environment. Ottawa: Minister of Supply and Services Canada.

Green, D. 1988. Determination of contaminant concentrations across the Niagara River using automatic *in situ* water samples. Final report. Unsolicited proposal, Department of Supply and Services Contract No. 02SE-KW405-7-9195. Dartmouth, Nova Scotia: Seastar Instruments Ltd.

Keating, M. 1986. To the last drop: Canada and the world's water crisis. Toronto: Macmillan of Canada.

Kuntz, K.W. 1988. Recent trends in water quality of the Niagara River. Technical Bulletin No. 146. Burlington, Ontario: Environment Canada, Inland Waters Directorate, Water Quality Branch, Ontario Region.

Kuntz, K.W. and I.K. Tsanis. 1990. Trends in nutrients, major ions, and physical water quality parameters in the Niagara River during the 1977–87 period. Water Pollution Research Journal of Canada 25(1):15–32.

Malcomson, R. 1987. Niagara in crisis. Canadian Geographic 107(5):10–19.

Niagara River Coordination Committee. 1990. The Niagara River Toxics Management Plan, 1990 update. New York: United States Environmental Protection Agency; and Toronto: Environment Canada and Ontario Ministry of the Environment.

Niagara River Remedial Action Plan Public Advisory Committee. 1991. The Niagara River — How did we get to this stage? Hamilton: Ontario Ministry of the Environment, Niagara River Remedial Action Plan Co-ordinator.

Oliver, B.G. and K.D. Nicol. 1984. Chlorinated contaminants in the Niagara River, 1981–83. The Science of the Total Environment 39:57–70.

OME/OMNR (Ontario Ministry of the Environment/ Ontario Ministry of Natural Resources). 1991. Guide to eating Ontario sport fish. Toronto.

Sonzogni, W.C., W. Richardson, P. Rodgers, and T.J. Monteith. 1983. Chloride pollution of the Great Lakes. Journal of the Water Pollution Control Federation 55(5):513–521.

Suns, K., G. Hitchin, and D. Toner. 1991. Spatial and temporal trends of organochlorine contaminants in spottail shiners (*Notropis hudsonius*) from the Great Lakes and their connecting channels (1975–1988). Ontario Ministry of the Environment, Water Resources Branch.

WHO (World Health Organization). 1993. Guidelines for drinking-water quality. Draft report. Geneva: World Health Organization.

Whyte, R.S. 1986. A statistical analysis of recent chloride trends in water samples collected from seven municipal water intakes drawing from Lake Erie. Presented International Conference Association for Great Lakes Research, May 1986, Toronto.

For further information

Supplementary information on water quality in the Niagara River may be obtained from the following address:
Water Quality Branch
Environment Canada, Ontario Region
867 Lakeshore Road
Burlington, Ontario L7R 4A6

Information on State of the Environment Reporting may be obtained from the following address:
State of the Environment Reporting
Environment Canada
Ottawa, Ontario K1A 0H3

Author: K.W. Kuntz

State of the Environment Reporting encourages "environmental citizenship" — a commitment to learn about the environment and engage in environmentally responsible activities at a personal level, within organizations, and within communities.

ENVIRONMENTAL CHOICE · CHOIX ENVIRONNEMENTAL

Over 50% recycled paper including 10% post-consumer fibre.

M - Official mark of Environment Canada

Published by Authority of the Minister of the Environment

Catalogue No. EN1-12/93-2E
ISBN 0-662-20561-8

Également disponible en français sous le titre :
Les tendances des concentrations de contaminants dans la rivière Niagara

Canada